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ABSTRACT

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RESEARCH REPORT: 14

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"THIS QUESTION IS JUST TOO. TOO EASY!" PERSPECTIVES FROM THE CLASSROOM ON ACCOUNTABILITY IN SCIENCE

BETH WARREN AND ANN S. ROSEBERY

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"This Question Is Just Too, Too Easy!"

Perspectives from the Classroom on Accountability in Science

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"This Question Is Just Too, Too Easy!"

Perspectives from the Classroom on Accountability in Science

Abstract

This paper will explore a form of classroom discourse, organized around student argumentation, that brings into focus an alternative view of science and science education as socially and culturally constituted, meaning-making activities. To elaborate the differences between this emerging discourse practice and conventional practice, we will consider two examples in which students and teachers grapple with the accountability of theories, facts, or claims to evidence. A key aspect of our analysis will be to examine the implications of Mikhail Bakhtin's core notion of dialogism for understanding student learning in science. In this way, we intend to illustrate how our perspective on learning in science is emerging through contact with socioculturally based theoretical perspectives and with the everyday experiences of teachers and students as they work to build sense-making communities in their classrooms.

INTRODUCTION

This paper will explore a form of classroom discourse, organized around student argumentation, that brings into focus an alternative view of science and science education as socially and culturally constituted, meaning-making activities. To elaborate the differences between this emerging discourse practice and conventional practice, we will consider two examples—one analyzed by Lemke (1990) in *Talking Science* and one drawn from our own work in bilingual classrooms in the Cheche Konnen project—in which students and teachers grapple with the accountability (Bazerman, 1988) of theories, facts, or claims to evidence. A key aspect of our analysis will be to examine the implications of Mikhail Bakhtin's core notion of dialogism (Bakhtin, 1975/1981, 1929/1984) for understanding student learning in science. In this way, we intend to illustrate how our perspective on learning in science is emerging through contact with socioculturally based theoretical perspectives (Bakhtin, 1975/1981, 1929/1984; Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Wertsch, 1991) and with the everyday experiences of teachers and students as they work to build sense-making communities in their classrooms.

CONVENTIONAL CLASSROOM PRACTICE IN SCIENCE

In his book, *Talking Science* (1990), Jay Lemke documents the forms of science talk that predominate in high school. Through his analysis, he shows that science and teaching are social processes dependent on attitudes, values, and social interests, not just on knowledge and skills. He also argues that science education perpetuates a view of science as objective, authoritative, and exclusive in the sense that it is presented in opposition to common sense and as comprehensible only to those possessing special talents. He makes the case that this ideology is maintained, sometimes unwittingly, through particular ways of talking science in the classroom–for example, Triadic dialogue (e.g., teacher initiation–student response–teacher evaluation)–and through the content of the science curriculum.

In the following example, Lemke shows how an ideology of science as objective, "factual" truth is enacted through the talk of both teachers and students. A high school earth science teacher unexpectedly finds himself engaged in a debate about the factual status of the idea that the earth's crust has been uplifted.

1	Teacher:	Now let's try and understand this answer
2		that I gave you here. It says, "Marine
3		fossils are found in mountains of high
4		elevations; this suggests that the crust
5		has been uplifted." It means the earth is
6		pushed up, OK? The earth is pushed up.
7		That's what we mean by uplifting.
8	Charley:	Couldn't the water go down?
9	Vito:	Yeah!
10	Teacher:	It's possible that the water level has gone
11		down, but we believe that the earth has
12		been uplifted.
13	Scott:	It's just a theory though.
14	Vito:	It's always a theory.
15	Teacher:	This, this is a fact. This is a fact, OK? This
16		is not a theory.
17	Vito:	It's a fact?
18	Scott:	Wait a minute, it can't be a fact. There's no
19		proof that the earth was raised up, unless
20		they took measurements.
21	Teacher:	They – measurements have been taken.
22	Scott:	Measurements have been taken?
23	Teacher:	Right now, OK? Now I'm gonna try 'n
24		explain you something else.
25	Robert:	How can you prove that that's a fact?
26	Teacher:	I'm gonna try and tell you what happens.
27		Just a second, Scott. Just listen carefully.
28		Somebody by the name of James Hutton
29		came out with a theory of Uniformitarian-
30		ism. Does anyone know what that means?

[IN OMITTED LINES THE TEACHER REJECTS THREE ANSWERS]

31 Teacher: OK. What Monica is trying to say, in one
32 sentence is, what James Hutton tried to
33 prove was: The present is the key to the
34 past. OK? We look at things, things that
35 are happening today, happened exactly
36 the same in the past. [Teacher repeats
37 this.] So the present is the key to the past.
38 So by looking, by looking at geologic for-
39 mations, we can tell, if things were uplifted,
40 uplifted, or things subsided. OK, just by
41 looking at them. And that's how, that's how
42 there's ways, in which they prove, that
43 things were uplifted, how can they tell they
44 were uplifted. All right, let's go on to our
45 question. (Lemke, 1990, p. 141)

Lemke analyzes how the debate over the status of crustal movement as theory or fact unfolds. A student, Charley, challenges the teacher's summary of crustal movement by offering an alternative theory that rather than the earth pushing up, the water goes down. The teacher's subsequent defense, couched in a language of possibility and belief rather than certainty, prompts other students, Scott and Vito, to question the scientific status of the teacher's statement as "fact" or "just a theory." Scott then links the determination of the statement's status to a notion of proof that derives from "measurements." The teacher replies that "measurements have been taken," and, in response to Robert's request for a proof of crustal movement's facticity, he goes on to invoke Hutton's theory of Uniformitarianism. With that "proof," he closes off debate.

Exactly why the teacher closes off debate in the way he does is not easily disentangled in our view. The opening of the episode seems to suggest that he is trying to get through some sort of review. That purpose may very well have conditioned his response to the students' challenges. On the other hand, he may be uncomfortable with the students' challenges; perhaps he is not really in command of the evidence he cites in support of crustal movement. Lastly, the teacher's own relationship to science as a form of knowledge or a way of knowing is not clear; his relationship to science may be no less authoritarian, neither more nor less examined, than that of the students.

Indeed, Lemke argues that, in their talk, the students and the teacher appear to differentiate theories and facts in similar ways. Theories are arguable, tentative, a matter of belief; facts are certain, not arguable, and objective, backed by measurements. Lemke notes that in lines 18-21, both Scott and the teacher seem to be saying that "a theory is no longer a theory when we have 'measurements,' i.e. data, observations" (p. 142). Theories and facts are thus unproblematically linked to measurements. But what of these measurements? Where do they come from, and how, we may ask, is their meaning taken? Directly from nature, it appears, "by looking." According to Lemke, this episode makes manifest a particular "ideology of evidence and authority" underlying much of classroom practice in science:

> The rhetoric of "evidence and proof" presumes that evidence itself simply exists, is found simply "by looking." It conveniently ignores that *people* always have to *decide* that something will count as evidence for something else. The notion of *proof* presumes that one particular kind of logic and argument embodies "necessary truths" rather than that such forms of argument are simply specialized genres, used by particular groups for certain purposes. (Lemke, 1990, p. 142)

Evidence, in short, is given, not constructed.

In Bakhtin's terms, the teacher's talk in this episode is authoritative:

> The authoritative word demands that we acknowledge it, that we make it our own; it binds us, quite independent of any power it might have to persuade us internally; we encounter it with its authority already fused to it. (Bakhtin, 1975/1981, p. 342)

The teacher's invocation of Hutton's principle functions in just this way. Whatever the complexities of the teacher's intentions might be, it is clear by the end of the episode that he means to persuade the students that the status of crustal movement as a fact is not modifiable, at least given the purposes operating at that moment. From line 26 to the end, Hutton's principle is delivered with its authority already con-

ferred; the effect of this move is to close off the possibility of argument, of considering either the theoretical or empirical basis for the proof.

Despite the teacher's assertion that crustal movement is a fact, a tension around theory and fact pervades his talk. Lemke points out that the teacher mixes the language of theory and fact ("theory," "prove," "what happens") in his closing monologue. In fact, this tension has been present from the very beginning, both within the teacher's utterances and in the interaction between his utterances and those of the students. Ironically, the teacher underscores the tension when he ends the debate, as Lemke points out, by proving a fact with a theory, contradicting his earlier position. We are left to wonder what might have happened had this tension, which the students brought out with their questions, been confronted. What might the students have come to understand about crustal movement on the one hand, and about the relations among theory, fact, and evidence on the other?

DIALOGISM

In this paper, we are concerned with exploring how an analysis of dialogism–which, according to Bakhtin (1975/1981, 1929/1984), characterizes all discourse–can illuminate important aspects of learning. We analyze a genre of classroom talk that we think provides an interesting counterpoint to the earth science lesson. It involves a form of group argumentation that emerged in a Haitian bilingual seventh and eighth grade classroom. We are concerned with understanding in what ways this case differs from that of the earth science lesson: specifically, in what ways the group's argument functions dialogically to bring into contact different points of view on what constitutes evidence (i.e., how claims are accountable to empirical evidence) and to open critical counter perspectives on what, from the claimant's point of view, is an unproblematic observation or fact. To set the analytic context, we first outline Bakhtin's thinking on dialogism.

Dialogism is a core concept in Bakhtin's theory of discourse (1975/1981, 1929/1984). One of the aims of our research is to explore the implications of this idea for learning. For as Bakhtin (see Volosinov, 1973, p. 102) has written, "any true understanding is dialogic in nature." What does this mean? First, in its most general sense, dialogism defines the relation between words and their objects and between participants in an interaction:

> Any concrete . . . utterance finds the object at which it was directed already as it were overlain with qualifications, open to dispute, charged with value. . . . It is entangled, shot through with shared thoughts, points of view, alien value judgments and accents. The word, directed toward its object, enters into a dialogically agitated and tension-filled environment . . . , weaves in and out of complex interrelationships, merges with some, recoils from others, intersects with yet a third group. . . .
>
> The living utterance, having taken meaning and shape at a particular historical moment in a socially specific environment, cannot fail to brush up against thousands of living dialogic threads, woven by socio-ideological consciousness around the given object of an utterance; it cannot fail to become an active participant in social dialogue. After all, the utterance arises out of this dialogue as a continuation of it and as a rejoinder to it — it does not approach the object from the sidelines. (Bakhtin, 1975/1981, pp. 276-77)

Utterances are thus complexly situated socially, culturally, and historically. And they are populated by intentions: those of the present speaker and those of others, both past and present. They participate in an ongoing dialogue; they are responsive to that history of spoken and written words. They are both shaped by it and give shape to it. For Bakhtin, an utterance is also importantly shaped by that which has not yet been said: the "answering word that it anticipates" (Bakhtin, 1975/1981, p. 280). Speakers and listeners are thus oriented toward one another in an attitude of responsive understanding, which may be expressed in complex relations of resistance or support. Such understanding is built on contact — what Bakhtin called "interanimation" — between the specific world views, values, expressive accents,

ways of speaking, and so forth of different participants in an interaction.

Secondly, in a more specialized sense, the idea of dialogism is tied to a pluralistic view of discourse. In this way, Bakhtin foreshadows contemporary sociolinguistic perspectives on discourse (Cook-Gumperz, 1986; Gee, 1990; Heath, 1983; Ochs, 1988): what Bakhtin himself referred to as "social languages" (1975/1981, p. 275). A discourse constitutes a specific point of view on the world. Each discourse is characterized by its own objects, meanings, and values; each has its own ways of conceptualizing and evaluating the world in words, in mathematical symbols, in the lines of a drawing, and so forth. Discourses may be juxtaposed with one another in various types of relations, including agreement, opposition, authority, parody, irony, and so on. When brought into contact in these ways, discourses and the world views they embody become subject to evaluation, revision, and refinement (Morson & Emerson, 1990). According to Bakhtin, this "interanimation" among discourses—of different points of view, voices, meanings, and values—is dialogism; and, as we noted above, it creates the ground for understanding, change, development, and learning.

Viewed from this perspective, the teacher's talk in the earth science lesson was authoritative in that it denied the possibility of sustained, critical interanimation among his viewpoint, his representation of Hutton's viewpoint, and the students' viewpoint(s). Different voices were certainly present in the discussion—even tensions within the same voice. But at various points, no more pointedly than at the end, the teacher closes off the possibility of interaction among the different voices; he does not allow the students to play with his representation of Hutton's view, to argue with it, to test it against their own ideas or other voices (e.g., the writings of Darwin, Gould, or Hutton himself). The teacher, in short, invokes Hutton authoritatively, as the final word. Perhaps more to the point, he speaks through Hutton, merging his own authority with that of the scientist.[1] If the students wish to continue the argument, they now must challenge the whole edifice of scientific authority, not just their teacher.

In the following sections, we explore more fully how a dialogically oriented analysis can open new perspectives on learning and help us make sense of what appear to be marked differences in the talk found in the earth science lesson and that found in our example of student argumentation. We will examine how a group of students and their teacher develop particular ways of making and presenting claims by putting into contact different points of view on accountability (Bazerman, 1988). By accountability, we mean (following Bazerman) how scientific claims about observed events can be made accountable to empirical evidence. We will pay particular attention to how norms for evidence are constituted in the dialogic interaction between differing perspectives. The analysis of this group's talk is intended to illuminate a way in which students and teachers may approach the question of accountability to evidence that differs significantly from that enacted in the earth science lesson.

The analysis that follows focuses on a discussion of a claim that one student, Scott, made about a population of snails he had taken home to observe. The discussion is structured as a series of challenges to Scott's initial claim and the subsequent modifications he makes to it. In these disagreement sequences (Lynch, 1985), Scott either deflects the criticism and maintains his claim or modifies it. These modifications in turn prompt additional challenges and modifications. The question of interest to us in analyzing this discussion is how, through these disagreement sequences, the argument functions dialogically to bring into contact differing perspectives on what it means for a claim to be accountable to evidence. Through such interanimation (Bakhtin, 1981), one perspective is evaluated from the point of view of another, creating a space within which new meanings can emerge.

BACKGROUND

Let us first set the context for the discussion. It took place in a seventh and eighth grade Haitian

bilingual classroom that participated in the Cheche Konnen ("search for knowledge" in Haitian Creole) project during the 1991-92 school year. In Cheche Konnen, teachers—bilingual, ESL, and a science specialist—and researchers are exploring ways to create communities of scientific practice in linguistically and culturally diverse classrooms (Rosebery, Warren, & Conant, 1992; Warren & Rosebery, in press; Warren, Rosebery & Conant, 1994). Among the questions we are addressing are the nature of such communities, how to create and sustain them, and the interrelationships among different discourses in relation to students' learning in such communities. By "communities of scientific practice," we mean classrooms in which students construct and refine their scientific understanding by investigating questions they have posed, developing and arguing evidence, negotiating claims, building and criticizing theories. The curriculum emerges from the students' own scientific activity and is shaped by both teachers and students.

What we — teachers, students, and researchers — are working toward are classroom communities in which students appropriate the discourse of science: a set of sociohistorically constituted practices for constructing facts, for integrating facts into explanations, for defending and challenging claims, for interpreting evidence, for using and developing models, for transforming observations into findings, for arguing theories. From this perspective, learning in science cannot be reduced to the assimilation of scientific "facts," or the mastery of scientific "process" skills, or the refinement of a mental model, or the correction of misconceptions. Rather, learning in science is conceptualized as the appropriation of a particular way of making sense of the world: of conceptualizing, evaluating, and representing the world.

The discussion presented here took place in June, at the end of the 1991-1992 school year. Haitian Creole was the first language of the 15 students and their teacher, Mr. S. In addition to other academic subjects, Mr. S. taught science to his students twice a week for an hour, starting in the spring term. Like many bilingual teachers, Mr. S. had limited experience with science, both as a learner and as a teacher. A relative newcomer to teaching, he had, in fact, never taught science before the 1991-92 school year. In the context of the Cheche Konnen project, however, he had spent a few months in the fall term studying aquatic ecology collaboratively with other teachers, a biologist, and other project staff.

In the classroom, the focus of science was also aquatic ecology. The students took field trips to a local pond to collect water and plant samples. Back in their room, they set up several aquaria which remained active until June. They spent approximately four months observing plant and animal life in their aquaria and investigating questions about individual species and community interactions in the pond. The students became particularly interested in snails, organisms that reproduced prolifically in their classroom tanks. Their observations led them to study aspects of snail development, reproduction, anatomy, and ecology.

The class engaged regularly in a routine of sharing and discussing individual students' observations, a routine that was distinctive to science and that drew on the students' evident skill in argumentation (Ballenger, 1994). Vigorous discussions frequently resulted in which a claimant was asked questions by the other students, sometimes to clarify and other times to challenge points. This routine of sharing observations is one that Mr. S. engaged in with his fellow teachers in the context of a twice monthly project seminar in which the teachers and project staff collaboratively explored scientific practice based on our own scientific activity and talk, on discussion of readings in science and about science, and on analysis of classroom scientific activity and talk (Warren & Rosebery, in press).

SCOTT'S CLAIM

Prior to the particular discussion with which we are concerned, one student, Murana, confessed that she had not done the observations needed to ad-

dress her question about whether snails are carnivorous ("Do snails eat meat?"). Scott, who had already reported to the class, replied that he had some data relevant to Murana's question and described an investigation in which he gave meat to snails. He went on to tell the class that he had been keeping a sample of snails at home. When he announced that he had 30 snails in his sample, the class was amazed. The teacher, Mr. S., asked him how many generations of snails he had, and Scott answered that he had at least three.[2] Murana then asked him how he knew he had more than one generation, and a lively discussion ensued.

"Lively" perhaps does not fully convey the character of the discussion or of the context as captured on videotape. The students were highly animated, frequently interrupting one another. We have tried to show some of the dynamics, but decided in the end to trade off accuracy of transcription for clarity and accessibility. Murana was actually milling around the back of the classroom for part of the discussion, until she was asked to sit down. There are moments of contagious, perhaps embarrassed, laughter, particularly when the students begin to talk about some mechanics of snail reproduction. The discussion is, in short, very messy; it does not have the orderliness characteristic of most classroom discussion.

But in its messiness, the discussion perhaps opens up for view some of the ways in which social identity is inextricably part of a student's learning identity (Eckert, 1990; Lave & Wenger, 1991; McDermott, 1993; Mehan, 1993). We are not going to explore this in any detail here, although we will comment on it some in our concluding remarks. For the moment, we simply want to provide some relevant detail on Scott's history within this class. According to Mr. S. (interview, June 3, 1992), prior to this discussion, Scott had not participated in any sustained way in science discussion. Usually Scott would take a turn, be challenged, give in, and become quiet. In this discussion, however, Scott's participation is of a different order altogether, although his credibility, as in previous class discussions, is still very much on the line.

The discussion took place in Haitian Creole. The text has been translated into English; the original transcription is included in the Appendix.[3]

June 1, 1992

Scott: OK, I am going to answer Murana's question. This question is just too, too easy.

Mr. S: Go ahead.

Scott: Murana's question, she asks how do I know there are two generations of snail? Me, I said, when the snails made eggs, the eggs hatched. And when I looked the snails were still there, because I know their colors. And the same baby made another baby and then the little babies laid eggs.

James: //Question!]

Mr. S: //But how—wait, wait . . .] —how did you identify them?

Scott: Hunh?

Mr. S: How did you identify them?

Scott: How?

Mr. S: Yeah.

Scott: I don't understand.

Mr. S: No, you say—okay —you have 30 snails.

Scott: *About 30.*

Mr. S: About 30. OK. So a mother made babies, right? She laid eggs. But how do you know that the grown babies— right, I don't know, at what size does a snail make babies? I don't know. //Would anyone here] like to know at what size they make babies?

Manel: //Yes.]

Scott: The babies are small

Mr. S: No, talk to the class. [ ] I don't know [ ].
Scott: = the little ones are smaller than //an ant.]

Mr. S: //Sit down, Murana.] Than what?

Scott: Than an ant.

Mr. S: OK.

36 **Manel:** And they made babies?

37 **Scott:** No, they grew and made babies.

At the point we enter the discussion, Scott has just asserted that in addition to his original snails he has two new generations of snails. Murana challenges him to explain how he knows that, and Scott eagerly takes up her challenge. In fact, he is so confident in this move that he treats her question dismissively (lines 1-2: "This question is just too, too easy"). Scott then proceeds in lines 4-11 to recount what he claims to have observed: that the babies born to the snails made other babies.

Scott's account is one of discovery, of "observations made upon undisturbed or unmanipulated nature" (Bazerman, 1988, p.66). For Scott, its meaning is simply, straightforwardly what he observed; the reported events—the snails made eggs/the eggs hatched/the same baby made another baby/the little babies laid eggs—constitute the "evidence" on which he rests his claim. To lend his account credibility, he uses two strategies. In one, he invokes his own authority as an observer (line 7: "when I looked"), and in the other he establishes his knowledgeability in this domain (lines 8-9: "because I know their colors").

Scott's account is immediately met with interest. James attempts to take the floor but is preempted by Mr. S., who asks Scott to specify his identification procedures. This marks the first, but not the last, call for specification of Scott's methods. Although Mr. S. initiates this line of questioning, he subsequently allows the conversation to unfold along lines the students themselves develop. When Scott says he does not understand the question, Mr. S. enlarges its scope from what Scott observed or knows (lines 23-24: "But how do you know that the grown babies . . . ") to a fundamental aspect of the biology of individual organisms, specifically, the reproductive cycle of snails (lines 25-26: "at what size does a snail make babies?"). He is in effect asking: "When are snails mature enough to reproduce?"

Thus, in this first sequence, Mr. S. places Scott's claim into motion around a central concern, namely, *how* Scott knows he has multiple generations; that is, by what method did he identify the different generations of babies? At the same time, he is indicating his own interest in the question and his appreciation for its authenticity; it is a question to which he, the teacher, does not have the answer. By inviting the students to express their own interest in the question, he establishes it as a genuine ground for inquiry rather than as an occasion for displaying known facts.

Scott deals with Mr. S.'s question by re-situating it within the context of his own observations (line 30: "The babies are small"). His response, however, proves problematic in light of Mr. S.'s reframing, as Manel (line 36) shows: If the babies are so small, how could they reproduce? In the face of Manel's challenge, Scott modifies his claim: (line 37) "No, they grew and made babies." With this modification, Scott unwittingly introduces a tension into his account, one which will later turn out to be pivotal in dismantling his claim. When he says, "they grew and made babies," it is unclear whether this is something Scott has observed and can describe or something he has improvised in the moment by way of explanation. As we will see, this modified account, although apparently effective in the immediate moment in disarming Manel's challenge, will cause Scott irremediable difficulties later on.

In the next disagreement sequence, James raises a question about the basis of Scott's claim.

(...)

38 **Mr. S**: Joel, um, James?

39 **James**: Yeah, here's what I say, Scott. What if the
40 babies made babies with the mother?

41 **Scott**: I can't say that. I can't talk about that. I said
42 there are two generations. That's what I
43 said. That's what I said. I didn't say any-
44 thing about babies having sex with their
45 mothers.

[Some commotion follows.]

At this point in the argument, Scott is able to deflect James's challenge by arguing not with the content but with its relevance or accuracy. James, of

course, never pretended to be quoting Scott. Rather, he was making a point, somewhat sensationally, about the need to know exactly who mated with whom, if Scott's claim is to be believed. In turning James's question into an instance of reported speech (Volosinov, 1973)—"I didn't say anything about babies having sex with their mothers"—Scott at one and the same time evaluates its content as well as its author. Suddenly it is James's reliability that is in question. James has in effect left himself open to this kind of move by not linking his challenge directly to Scott's account, and Scott takes advantage. For the moment at least, Scott wins the round. But he will hear this line of questioning again, when it is recast in terms of a more articulated biological perspective and tied directly to his own words.

In lines 46-97, Manel launches an interrogation into the material basis of Scott's assertion, that is, what exactly Scott did, how many snails he had originally, how many babies the snails made each day, and so on.

46 **Mr. S**: Manel?

47 **Manel**: I have a lot of questions for Scott.

48 **Scott**: Yes?

49 **Claudie**: Give two.

50 **Manel**: I ask you, when you took them, how many
51 did you go home with in the first place?

52 **Scott**: Oh, I took a big – I could have taken about
53 10 or 5 like that.

54 **Mireille**: //[ ] Scott who went and [ ]?]

55 **Manel**: //Can you say how many] babies they
56 made each day?

57 **Scott**: How many babies they make each day?
58 How would I know? They make them in
59 egg masses.
60 **Manel**: And you say //that you have 30?]

61 **Murana/Mireille**: //How did you count them?] How
62 did you count them?

63 **Claudie**: No, when snails lay eggs there are lots of
64 masses, don't you know that?

65 **Manel**: No–

66 **Claudie**: There are many masses.

67 **Manel**: No–

68 **Mireille**: Let Scott defend himself!

69 **Claudie**: No, if it's something I've seen, it's normal
70 for me to say something.

71 **Manel**: No, Scott should tell me //how many they
made] because you had 10 =

72 **Mireille**: //Scott is supposed to defend himself.]

73 **Scott**: You know why I said there were 30?
74 Because the babies of the babies, the
75 ones that were just born, I counted them.
76 That's it I counted them because, because
77 I used to see them stick to the sides of the
78 container.

79 **Manel**: = OK, Mr. S – Scott, I believe Scott is lying.

80 **Mr. S**: //Why?]

81 **Scott**: //No I'm not.]

82 **Manel**: Because, listen! You have 10—//listen,
83 listen, listen, listen]

84 **Scott**: //OK, OK, OK, OK.] I'll bring them tomor-
85 row if you want, [ ] all the snails [ ].

[Commotion]

86 **Mr. S**: Listen, let him speak [ ]. Go ahead.

87 **Manel**: = you have 10 snails. When you look into
88 what you put them in you have 30. What
89 about the rest of them, the rest didn't make
90 babies?

91 **Scott**: I said about 30. Isn't that what I said?

92 **Manel**: No, I ask you, did the rest make babies?

93 **Scott**: Yes, they made babies.

94 **Manel**: [ ] made babies?
95 **Scott**: *Some* made babies.

96 **Manel**: What about the rest of them?

97 **Scott**: The rest of them? I don't know.

98 **Manel**: [ ]

[Some students giggling]

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In this sequence, Manel seeks to establish how many snails Scott started with and how many babies they made each day. Manel does not believe that Scott, who says he started with 5 or 10 snails, can now have 30. It seems that Manel is concerned with figuring out whether 30 snails is enough given the initial conditions. By the end of this sequence, Manel leads Scott into what turns out to be a crucial modification of his original assertion. Let's look at how this sequence unfolds.

Scott answers Manel's challenge about the number of babies the snails made each day with a rhetorically framed assertion of fact (lines 57-59). In this case, Scott's assertion is supported by another student, Claudie, who in lines 63-64 aligns himself with Scott by challenging Manel's knowledgeability (Goodwin, 1990). In this sequence, we also see Claudie arguing for a norm that allows students other than the "defendant" to bring forth evidence (lines 69-70). Manel rejects Claudie's argument because for him the argument rests precisely on what *Scott* has seen and on *how* he accounts for his observations.

In his challenge, Manel demands specific details from Scott about his work. In lines 73-78, Scott provides the basis for his conclusion that there were "about 30" snails. He describes the method he used to collect those data and why he believes it was effective. Manel remains unconvinced and accuses Scott of lying. Scott denies the accusation and offers to bring in the snails to demonstrate the truth of his claim. It is as if Scott is saying that once the other students see the snails they will agree that they see what he claims to have seen. Paraphrasing Bazerman (1988, p. 5), Scott's offer betrays a belief that the scientific claim merely points to a self-revealing nature, that seeing is believing. The proof, in short, is in the showing.

Scott seems to realize at this point that he needs to produce something beyond his own account, that his word alone cannot establish his credibility. But Manel is not satisfied by Scott's offer. He persists in trying to make the numbers, as he sees them, come out right. In fact, he takes Scott's own justification and builds the beginning of a new argument (lines 82-96), namely, that what needs to be specified here is not how *many* snails there are (perhaps he is conceding this point to Scott) but *which* snails actually made babies. In response, Scott modifies his assertion a second time to "*some* made babies," an example of equivocation in Scott's discovery account. Is this modification based on observation or is it improvised?

Scott's modification provokes a challenge from Mireille. Her question (lines 99-100) crystallizes the central issue on which both Scott's original and modified assertions rest:

99 **Mireille**: How do you know which made babies and
100 which didn't make babies?

In order to establish that he in fact has three generations of snails, Scott *must* be able to answer Mireille's question. The debate all along has been over whether what Scott has reported actually happened. Within the context of this argument, Mireille demands a new level of accountability. She is not just asking Scott to identify which made babies and which didn't; rather she is asking him to provide the evidential basis for his statement. Her question makes it clear that *how* Scott knows is essential to her assessment of *what* Scott knows.

After a sidetrack during which another student tries to answer Mireille's question by explaining that snails are hermaphroditic (which we omit here for brevity's sake), Darlene returns the discussion to the main line of argument (lines 101-128). She anchors her question in Scott's claim to have 30 snails and, building on Mireille's challenge, initiates a related disagreement sequence. This line of questioning echoes the one first suggested by Mr. S. at the beginning of the discussion: "At what size does a snail make babies?"

(...)

101 **Darlene**: But like if you say you have 30 snails

102 **Scott**: Uh hunh.

103 **Darlene**: = in how much *time* did each snail make
104 babies? //Like] if a snail is born today,
105 tomorrow can it have a baby?

106 **Asline**: //Yes Scott.]

107 **Mr. S**: //Good question.]

[Commotion, students cry out, some hoot]

108 **Scott**: I said that! I said *when they grew up*. I said
109 when they grew up they made babies.

110 **Mr. S**: OK, kids, can I say something? That's
111 something I would like to know because
112 we are doing research on that question (in
113 the teachers' group). I would like to know—
114 good question—respond Scott [ ].

[Renewed commotion]

115 **Scott**: OK, me, here's what I said, when [ ] asked
116 me this, when [ ] asked when the snails
117 are born can they just turn around and
118 make babies right then? I said no. I said
119 it's when they grew up that they made
120 babies because, because I used to put–

121 **Darlene**: //Let me ask you a question before you finish answering.]

122 **Scott**: //Won't you let me finish?]

123 **Darlene**: Before you answer it like that, let me ask
124 you something while you're saying that.
125 Like if you say they made babies, that's
126 what you said, how much time does it take
127 a snail to grow up?

128 **Scott**: How could I know?

129 **Darlene**: Well, then, //Scott]

130 **Scott**: = //Snails are always small.]

Darlene reaccents Mr. S.'s earlier question, which he framed in terms of size, in terms of the time it takes for a snail to reach sexual maturity. She asks both about Scott's snails specifically and, to clarify her point, about snails in general. Echoing Mr. S.'s line of inquiry, Darlene situates the proof of Scott's claim in relation to the biology of snail reproduction (lines 103-105); in effect, she is asking what *model* of snail development underlies Scott's claim. In response, Scott repeatedly insists on the letter of his prior statements, that "when (the snails) grew up they made babies." In his denial, Scott is asking to be held accountable for only those things he actually said; he is attempting to reject the relevance of Darlene's question.

Mr. S., however, intercedes at this point (lines 110-114) to support emphatically the relevance of Darlene's question. Why? We would argue that, by reformulating Mr. S.'s earlier challenge, Darlene refocuses the conversation onto a point he considers to be critical in establishing the credibility of Scott's claim. Mr. S. links Darlene's question to his own work, marking it as something of interest, outside his own knowledge. Mr. S.'s allusion to his research group—the group of teachers with whom he works in the Cheche Konnen project—may also be taken to suggest that Scott's work does not exist in a vacuum, but in relation to the work of others and to a developing body of knowledge. Thus, by taking the floor in this way, Mr. S. lends Darlene's question scientific, pedagogical, and personal authority; it underscores the crucial place her call for a model of snail development has in deciding the credibility of Scott's claim. He is, in short, letting Scott know that Darlene's question is one with which he must contend.

Scott recognizes the need to respond (line 115: "OK, me, here's what I said"). He then proceeds to replay in his own words Darlene's question and his reply. He attempts to further explain his thinking but is interrupted by Darlene, who in lines 123-127 repeats her question, presumably because Scott has not yet clarified what it means for a snail to "grow up." Interestingly, she invokes Scott's own strategy of owning or disowning particular statements ("I didn't say that!" "Here's what I said") to redirect the point of the discussion to the question of growth (Goodwin, 1990; Volosinov, 1973): "Like if you say they made babies, that's what you said, how much time does it take a snail to grow up?" (lines125-127). Unless Scott can address this question, either with some form of convincing evidence or with an elaborated model of snail development, he will not be able to escape the circularity of his own account. It appears from Scott's subsequent reply (lines 128 and 130) that Darlene has made her point. Scott admits that this is something beyond his ability to know, because "snails are always small." But the question of identification is precisely what has been at issue throughout this discussion. In order to elevate his

claim that he has multiple generations of snails to the status of fact, he needs to be able to distinguish "which snails made babies and which didn't make babies." This he apparently cannot do given the data he has at hand.

In this final sequence, Darlene is, in effect, holding Scott accountable to his words while at the same time reaccenting them to serve her own argumentative purpose (Volosinov, 1973). Ironically, this has been Scott's defensive strategy all along, one by which he disarmed his earlier critics. Darlene turns the table on Scott by directly taking up his account (as Manel had done earlier, forcing a modification). She challenges his use of the term "growth" to explain the change in population. On both sides of the argument, then, the students are taking the unfolding discourse as a form of public record (a factual record) that can be used at any point to argue for or against a given claim or challenge.

How does Darlene make her point? Throughout the discussion, Scott repeatedly invokes the notion of growth in a general sense, perhaps by analogy to human beings, to support his claim. The requirements of the logic of general biology as he understands it argue that snails—like any living organism—grow and (when they grow up) they make babies. When Darlene invokes the same notion, she does so within a different referential perspective (Wertsch, 1991); she is asking Scott to specify what growth means in relation to a snail's reproductive life. Her referential perspective is that of snail biology; Scott's is more general, having to do with a logic of reproduction applicable to living organisms in general. Darlene's use of Scott's words functions analytically to place them in relation to the meaning of growth in the context of snail biology. Darlene does not quarrel with the idea of growth per se, but with its particular meaning in the case under discussion. When at the end Scott wonders aloud *how* he could know how much time it takes for a snail to grow up, given that snails are always small, he brings into sharp relief the point of Darlene's probing. What, then, does it mean to say that snails "grow up" and, importantly, how can one tell? Scott wants to argue his claim logically, but the students are demanding that, if he is to persuade them of its facticity, he must argue it empirically in relation to the biology of snail reproduction. In short, the students' challenges emphasize the centrality of models, methods, and data in establishing and evaluating claims about their scientific activity.

DISCUSSION

In *Laboratory Life*, Latour and Woolgar (1986) argue that scientists transform their observations into findings through argumentation and persuasion, not simply through measurement and discovery. They portray the activity of scientists within a laboratory as a constant struggle for the generation and acceptance of fact-like statements. Their account details how in laboratories the facticity of a statement is constructed (or deconstructed) through the "superimposition of several statements or documents in such a way that all the statements are seen to relate to something outside of, or beyond, the reader's or author's subjectivity" (p. 84). These documents (e.g., histograms, spectra, peaks, recorded numbers, etc.) are obtained from what they call "inscription devices" (e.g., bioassays, spectrometers, etc.) generated within the laboratory or from papers written by investigators outside the laboratory; they are the means by which scientists convince others within their community to take up their claims, to pass them along, to make them more or less of a fact. Showing—of things which are not present or not visible— is inseparable from telling (Latour, 1986).

The problem of inscription seems to describe at least part of Scott's predicament. In the discussion around his claim, we see that beyond a certain point, Scott's only recourse in the face of continued challenges is to refer back to his own prior account or to modify it according to a logic outside his own experience of discovery. The vague, general language in which he couches many of his responses leaves him vulnerable to criticism. The difficulty he faces is to figure out what would constitute a persuasive ac-

count, what methods, model, and data he would need to establish his claim as relating to something outside his own experience or subjective evaluation, and how he might present his claim (e.g., forms of stating evidence). The problem of inscription, as outlined by Latour (1986), includes how to define and mobilize resources (e.g., records of population change, reproductive rates for individual snails) that can be displaced from the object itself, presented, and read. Needless to say, mobilization, presentation, and readability themselves open up layers of complexity. It is not a question of merely having an inscription, but of how one comes up with it, what sense one makes of it, how one explains it, and what others take it to mean (Collins & Pinch, 1993; Latour, 1983; Monk & Nemirovsky, in press; Nemirovsky, in press).

One result of the argument is that, at least as far as the other students are concerned, Scott's assertion is reduced from what to his mind was a self-evident fact to a disputable—and potentially investigable—claim (Latour & Woolgar, 1986). At the same time and as part of the same argumentation process, the class begins to construct norms for what it would take to transform a claim like Scott's into a "fact." These norms argue for evidence that can be mobilized (Latour, 1986) to lift a statement (e.g., "the babies made other babies") outside of the claimant's own subjective assessment into an inspectable and presentable (Latour, 1986) "objective" realm (e.g., "which ones made babies and which didn't")—one that is accountable empirically.[4] Specifically, the standard they are constructing calls for the evidence and the methodology on which Scott's account and its modifications rest. How did Scott come to be convinced of his discovery and for what reasons? Further, it situates Scott's discovery in relation to a specific body of knowledge, that of snail biology, rather than to a more generalized domain of growth and reproduction.

We do not think we can claim that Scott comes to understand fully the implications of the class's emerging norm within the course of the discussion. His own words — "How could I know?" — testify more than once that he does not know what to do with the students' challenges. His understanding, however, is not static; by the end of the segment, the certainty of his claim has clearly been shaken. On the basis of his teacher's testimony, moreover, it appears that this conversation proved to be something of a watershed for Scott; rather than withdrawing in the face of a challenge, Scott stayed in the argument, at times fending off the students' challenges, at others moving the discussion forward with his modifications. Scott may not have been able to answer the later, more consequential challenges, but he at least believed he had something worth defending.

In addition, by staying in the argument, Scott helped the class bring to the surface important facets of scientific accountability. Through their discussion, the participants put into contact two viewpoints on accountability, one represented by Scott and the other by his challengers, including the teacher. The challengers' perspective—its increasing specificity —emerges dialogically through the interplay between their questions and Scott's modifications. Similarly, Scott's viewpoint is problematized in the process, as he seems to realize by the end when he pleadingly asks: "How could I know? Snails are always small." Earlier he implied he could distinguish snails by their size. In responding to Darlene's challenge, he ends by talking himself into a contradiction.

Thus, the key contrast in the discussions of Scott's claim and of crustal movement lies in the way in which their respective arguments about the relationship of "facts" to evidence are taken up. In Lemke's earth science lesson, the disputability of a scientific fact is foreclosed and with it the possibility of problematizing assumed relations among theory, fact, and evidence. In the discussion of Scott's snails, by contrast, the relations among claim, fact, and evidence are precisely what is negotiated as different points of view are brought into contact with one another. The central underlying problem with which the students grapple is what constitutes accountability in the science they do. Admittedly, these two cases are not entirely equivalent. Scott's claim, for instance, clearly does not carry the same scientific authority as does crustal movement or Hutton's

principle. Thus it is not surprising that Scott is energetically questioned by his classmates. Yet in the earth science lesson, the facticity of crustal movement is also disputed, creating what turns out to be an unrealized opportunity for considering the nature of the relationships the students themselves are calling into question.

That argument can function dialogically to help define a community's practice—specifically, its norms of evidence—by bringing into contact differing perspectives and making those differences explicit is supported by Bazerman's (1988) analysis of the emergence and transformation of the written experimental report from 1665 to 1800. He explores the development of this genre of scientific discourse in terms of changing notions of accountability: that is, the constraints operating within particular socially and historically situated communities on how scientists present written accounts of nature. According to Bazerman, within a span of about 150 years, experimental accounts changed in character from uncontested reports of observed events ("cookbook recipes for creating marvellous effects or effects of practical use," p. 66) to intentional investigations, to tests of theory, and finally to proofs of claims. He describes how the genre developed as experiments began to assume a more argumentative function. For example, challenged by disagreements, scientists such as Newton began to explain more fully the methods of their experiments, the rationales for those methods, and the conditions under which the experiments took place. Thus, argument helped forge norms for accountability within the genre of the experimental report

> [by pushing] the individual author into recognizing that he is not simply reporting the self-evident truth of events, but rather is telling a story that can be questioned and that has a meaning which itself can be mooted. The most significant task becomes to present that meaning and persuade others of it. (Bazerman, 1988, p. 78)

In this sense, the discussion of Scott's claim and that of crustal movement are distinctly different. In the crustal movement discussion, differences in viewpoint and contradictions internal to a given viewpoint are not openly contested. In the discussion of Scott's claim, by contrast, differences are not just expressed, they are fully engaged in argument. The students specify differences in meaning for crucial terms (e.g., what it means to "grow up") that bear on the model of growth underlying Scott's claim; they question Scott's methods; and they begin to formulate norms of evidence for discovery accounts like Scott's.

Nevertheless, the discussion of Scott's claim is not without problems. Most crucially, Scott's final plea—"How could I know?"—goes unanswered. The discussion took place in June, just a few days before most of the students graduated from eighth grade. Consequently, no further work on Scott's claim was undertaken. In theory, however, and no doubt unwittingly on Scott's part, his question creates an opening that could provide him with the means to construct a credible account. It also provides an opportunity for all the students to learn how claims are investigated and established as facts in science. Scott clearly does not know "how to know" in this case; nor is it clear that the other students know any better how to take their challenges and formulate them in relation to Scott's claim in such a way that the claim becomes investigable. In this sense, the discussion of Scott's claim brings the class to a critical boundary in the appropriation of scientific discourse, one they cannot cross by themselves. But their teacher can explicitly coordinate the students' understandings and ways of talking with those of science; it is through such scaffolding that the students can learn to do what they don't already know how to do (Brown & Campione, 1994; Gee, 1994; Palincsar & Brown, 1984).

What direction might such scaffolding take? This question has been raised many times in discussions we have had with teachers and other researchers in the last two years about Scott's claim. From these discussions, we have drawn several implications for practice, specifically, for ways that a teacher might assist the students in seeing Scott's plea in relation to a more elaborated, sociohistorically devel-

oped set of practices for empirically investigating claims. In the case of Scott's claim, a teacher might want to affirm publicly the new perspective that the students' challenges have defined in relation to his claim: How much time does it take for a snail to reach sexual maturity? One way to accomplish this would be to engage the students in summarizing explicitly the problems they have exposed with Scott's claim (e.g., the nature of his evidence, his methods, his model of growth), then link those criticisms with scientific practices. This kind of analysis could extend to the various students' challenges as well as to Scott's claim itself. In our view, each of the students' criticisms bears importantly on core aspects of scientific practice, for example, on the relation of claims to evidence, on what counts as an explanation in science, and on how questions and hypotheses in science are typically constrained by some view or model of a system of underlying relations, in this case, the reproductive cycle of snails.

One route, for example, might be for the class to uncover the concerns implicit in a challenge like Manel's: "Can you say how many babies they made each day?" As stated, Manel's challenge seems to have rhetorical force, but it is unclear to what extent it has scientific force. Why, according to Manel, is it important for Scott to be able to say *how many* babies *each* snail made *each* day? This is a strong call for detailed quantitative data, but to what specific end? Is Manel asking a question about the nature of the evidence one needs to be persuasive and its relationship to methodology? These questions assume a scientific perspective that has not been made explicit in the discussion. Similarly, the other students, Darlene especially, make the point that it is the particulars of growth in snails—the underlying model of growth—on which any assessment of Scott's claim depends. Darlene situates her criticism in an explanatory framework of snail biology, whereas Scott bases his defense on some general notion of growth. What does Scott make of this distinction? What do the other students make of it? These sorts of distinctions are powerful in delineating scientific from everyday ways of knowing and arguing; making them explicit, a part of the public record, might help Scott and the other students understand why his use of "grow up" turned out to be vulnerable to a criticism like Darlene's.

Having summarized differences in the meanings and uses of evidence, models, and methods, the class might then proceed to address the question that arose out of their criticisms: How long does it take for snails to become sexually mature? To begin, they might discuss different models of growth that could drive their investigation and use these to constrain the investigation's design. How might the class take up this question? In another school that same year, the teachers and students in a combined Grade 5-6 Haitian bilingual class designed and conducted a related study to determine the size at which snails made babies. In developing their study, the students grappled with the always complicated problem of defining a methodology adequate to their question: how to design a study that would yield the kinds of data they would need to answer their question. They isolated snails of different sizes, ranging from 1mm to 9mm, in nine petri dishes. They discussed the importance of providing each with a suitable environment and comparable food supply. They agreed to observe the snails daily to see if any produced egg masses. They measured the size of each snail once a week to see if they had grown enough to require "reclassification" (transfer to another petri dish containing snails of the next larger size). In the end they decided that, on the basis of their data, they could safely conclude that snails 7mm to 9mm in length are capable of reproduction. However, they ran into difficulty interpreting their data for shorter lengths, because some students mixed snails of different sizes. One group of students combined 3mm and 5mm snails in one dish. Although egg masses were produced in the mixed case, the class decided to disqualify the result because it violated the design criteria they established for their study; they could not determine which of the different size snails made babies.

In the light of this investigation, work like Scott's, however flawed, can be seen as a useful, preliminary observation or exploration that can lead to more formal inquiry. Learning the differences between

these two forms of inquiry is an important move in bringing the students and their work into closer contact with scientific practice. Work along more formal lines also prepares the way for considering core ideas in biology and ecology, for example, relations among niche, reproductive effort and strategies, and natural selection that underlie the question of why snails have so many babies.

There are, in short, at least two important and related directions for teachers to pursue with discussions like the one this class had about Scott's claim. One is close and public inspection of the substance of the discussions themselves. The purpose is to bring out distinctions in meaning, to construct shared understandings, to make underlying assumptions about methodology, norms of evidence, and explanatory models explicit, broadly, to coordinate the students' ways of knowing and talking with those of science. A second, related direction entails a level of communal reflection and evaluation on the place and function of argumentation in science. Why is argumentation so important? What constitutes a scientific argument? What does it mean to be persuasive in a scientific argument? Why should it matter? Why, for example, don't the "facts" speak for themselves, as Scott would like them to? And in what ways is persuasion in science distinctive or not from everyday forms? Mastering the discourse(s) of science requires action and reflection at both of these levels.

Before concluding, we want to raise a final issue. We alluded earlier to the relation between learning and social identity (Eckert, 1989, 1990; McDermott, 1993), although we have not elaborated the point in this paper. And yet if one watches the videotape of Scott's claim, it is clear that social identity is very much on display and at stake. We have, for example, talked about the credibility of Scott's claim. But in this analysis, we have not linked the intellectual judgment to a more personal one, even though there are strong suggestions in the transcript that we should (e.g., as when Manel accuses Scott of lying). Who is Scott within the social organization of the classroom (not to mention beyond) such that he is seen as not being very credible and such that he has been to this point unwilling to argue his position in a sustained way? And what is it about the social organization of science in this class that allows Scott finally to put himself on the line? How is it that science (of all things) may be a means by which Scott can at least attempt to re-constitute his social identity? Are there aspects of the class's discussion or their scientific practice that might need adjusting (e.g., less personalized challenges, more explicit scaffolding of how to construct and mobilize inscriptions) in order for Scott to gain credibility? Or perhaps the personalized forms of argument—in which social intentions are enmeshed in arguing and challenging scientific claims (Ballenger, 1994) — are the ways in which the students "populate" scientific discourse with their own intentions and purposes (Bakhtin, 1981)? Ballenger (1994) has suggested, following Bakhtin, that if one cannot populate a discourse with one's own intentions, then perhaps one cannot take on the discourse. We raise these as questions for further thought. At the very least they remind us of the kinds of questions that arise when learning and knowing are viewed as socially organized activity, constructed in relations among people, activities, tools, symbolic systems, and the social world in and with which they act (Lave, 1990). They remind us further that the ways in which resources for learning are structured within any given context will importantly shape participants' identities within that context (McDermott, 1993) and, we might add, shape the meaning of science itself within any particular community.

In conclusion, we would argue, as did Mireille in challenging Scott's claim, that what the students in these two cases learn about the biology of snails or crustal movement on the one hand and about the relations among theory, fact, claim, and evidence on the other is inextricably tied to how they learn and how they use their learning. We think a focus on dialogism may open new perspectives on what it means to say that learning is situated: constituted in and through the activity, context, and culture in which it is developed and used (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). We have tried, through our analysis of Scott's claim, to bring into focus the

heterogeneous character of situated activity and its relation to learning (Lave, 1993): in particular, the multiplicity of viewpoints represented by the participants in any given situation and the various ways in which these viewpoints may interact dialogically to deepen, or perhaps more to the point argued here, to problematize understanding.

REFERENCES

Bakhtin, M. (1981). *The dialogic imagination* (C. Emerson & M. Holquist, Trans.). Austin: University of Texas. (Original work published 1975)

Bakhtin, M. (1984). *Problems of Dostoevsky's poetics* (C. Emerson, Trans.). Minneapolis: University of Minnesota Press. (Original work published 1929)

Ballenger, C. (1994). *Argumentation in a Haitian bilingual classroom.* Manuscript submitted for publication.

Bazerman, C. (1988). *Shaping written knowledge.* Madison: University of Wisconsin Press.

Brown, A.L., & Campione, J. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: MIT Press/Bradford.

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Collins, H., & Pinch, T. (1993). *The Golem: What everyone should know about science.* New York: Cambridge University Press.

Cook-Gumperz, J. (Ed.). (1986). *The social construction of literacy.* Cambridge: Cambridge University Press.

Eckert, P. (1989). *Jocks and burnouts: Social categories and identity in the high school.* New York: Teachers College Press.

Eckert, P. (1990). Adolescent social categories—Information and science learning. In M. Gardner et al. (Eds.), *Toward a scientific practice of science education* (pp. 203-217). Hillsdale, NJ: Lawrence Erlbaum.

Gee, J.P. (1990). *Social linguistics and literacies: Ideology in discourses.* London: Falmer.

Gee, J.P. (1994, April). *Science talk: How do you start to do what you don't know how to do?* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Goodwin, M. H. (1990). *He-said-she-said: Talk as social organization among black children.* Bloomington: Indiana University Press.

Heath, S.B. (1983). *Ways with words: Language, life, and work in communities and classrooms.* New York: Cambridge University Press.

Latour, B. (1983). Give me a laboratory and I will raise the world. In K. Knorr & M. Mulkay (Eds.), *Science observed: Perspectives on the social study of science* (pp. 141-170). Los Angeles: Sage.

Latour, B. (1986). Visualization and cognition. *Knowledge in society: Studies in the sociology of culture past and present, 6,* 1-40.

Latour, B., & Woolgar, S. (1986). *Laboratory life: The social construction of scientific facts.* Princeton, NJ: Princeton University Press.

Lave, J. (1990). Views of the classroom: Implications for math and science learning research. In M. Gardner et al. (Eds.), *Toward a scientific practice of science education* (pp. 251-263). Hillsdale, NJ: Lawrence Erlbaum.

Lave, J. (1993). Introduction. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 3-32). New York: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York: Cambridge University Press.

Lemke, J. (1990). *Talking science: Language, learning and values.* New York: Ablex.

Lynch, M. (1985). *Art and artifact in laboratory science.* London: Routledge & Kegan & Paul.

McDermott, R. (1993). The acquisition of a child by a learning disability. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 269-305). New York: Cambridge University Press.

Mehan, H. (1993). Beneath the skin and between the ears: A case study in the politics of representation. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 241-268). New York: Cambridge University Press.

Monk, S., & Nemirovsky, R. (in press) The case of Dan: Student construction of a functional situation through visual attributes. *Research in Collegiate Mathematics Education.*

Morson, G.S., & Emerson, C. (1990). *Mikhail Bakhtin: Creation of a prosaics.* Stanford, CA: Stanford University Press.

Nemirovsky, R. (in press). On ways of symbolizing: The case of Laura and the velocity sign. *Journal of Mathematical Behavior.*

Ochs, E. (1988). *Culture and language development.* Cambridge: Cambridge University Press.

Ochs, E., Gonzales, P., & Jacoby, S. (in press). "When I come down I'm in the domain state": Grammar and graphic representation in the interpretive activity of physicists. In E. Ochs, E.A. Schegloff, & S. Thompson (Eds.), *Interaction and grammar.* Cambridge: Cambridge University Press.

Palincsar, A.S., & Brown, A.L. (1984). Reciprocal teaching of comprehension-fostering and monitoring activities. *Cognition and Instruction, 1* (2), 117-175

Rosebery, A.S., Warren, B., & Conant, F.R. (1992). *Appropriating scientific discourse: Findings from language minority classrooms* (Research Rep. No. 3). Santa Cruz, CA and Washington, DC: National Center for Research on Cultural Diversity and Second Language Learning.

Volosinov, V.N. (1973). *Marxism and the philosophy of language.* Cambridge, MA: Harvard University Press.

Warren, B., & Rosebery, A.S. (1995). Equity in the future tense: Redefining relationships among teachers, students and science in language minority classrooms. In W. Secada, L. Fennema, & L. B. Adajian (Eds.), *New directions in equity for mathematics education* (pp. 298-328). New York: Cambridge University Press.

Warren, B., Rosebery, A., & Conant, F. (1994). Discourse and social practice: Learning science in language minority classrooms. In D. Spener (Ed.), *Adult biliteracy in the United States* (pp. 191-210). Washington, DC and McHenry, IL: Center for Applied Linguistics and Delta Systems.

Wertsch, J. (1991). *Voices of the mind: A sociocultural approach to mediated action.* Cambridge, MA: Harvard University Press.

NOTES

1 A stronger reading of this move has been suggested to us by Patrick Gonzales (personal communication, August 1, 1994). Rather than merging with Hutton's authority, the teacher may actually be deferring to it—a shift in responsibility by which he tries to achieve authority he may not feel he has. Read in this way, the teacher's move displays a stance toward scientific authority that is uncritical.

2 The way Scott talks about the number of generations he claims to have is confusing. In line 4, he claims to have two generations of snails, whereas in lines 6-7 he says that "the same babies made other babies," which suggests three generations. It seems clear from the conversation that the dispute is over whether the babies of his original snails had babies, that is, whether there are three generations.

3 The transcription conventions we use are as follows:

//]	indicates overlapped speech
–	placed at point of self-interruption
italics	mark stress
[ ]	unintelligible speech
(...)	omitted segment
=	latched utterance

4 Subject-object relations in scientific practice are not necessarily best conceptualized as dichotomous. In a study of the discursive practices of a university-based physics research group, Ochs, Gonzales and Jacoby (in press) argue that physicists actively express their subjective involvement with the objects they study through indeterminate referential constructions that mediate their interpretive activity (e.g., "When I come down I'm in the domain state"). The effect is to blur the boundaries between themselves as subjects and physical systems as objects.

APPENDIX

SCOTT'S CLAIM (HAITIAN CREOLE TRANSCRIPTION)

Lines 1-37

Scott: OK, kèsyon Murana, m a reponn li, kèsyon Murana two, two, fasil.
Mr. S: Pale non.
Scott: Kèsyon Murana, li di konsa, ke, koman m fè konnen gen grann grann. Mwen menm, nan, lè kalmason yo fè zè a, zè a kale, e, lè m gade yon kalmason toujou rete la, paske, m konn koulè yo, e menm pitit la vinn fè yon lot pitit, kounyea li vinn ponn zè, ti pitit yo vinn ponn zè.
James: //Kèsyon!]
Mr. S: //Men kijan - tann, tann, talè talè...] - kijan pou ou idantifye yo?
Scott: Hunh?
Mr. S: Kijan pou ou idantifye yo?
Scott: Koman?
Mr. S: Yeah.
Scott: M pa konprann.
Mr. S: Non, ou di - ok - ou genyen 30 kalmason.
Scott: *A penn de* trant yo.
Mr. S: A penn de trant yo. OK. Donk, manman an vinn fe pitit la, pa vre? Li ponn zè. Men kijan ou fè konnen ke, ti pitit grandi yo - pa vre, kounyea-ki gwo, mwen pa konnen, a ki gwosè li fe pitit? Mwen pa konnen. //Eske gen moun ki] ta renmen konnen a ki gwosè yo fe pitit?
Manel: //Wi!]
Scott: Ti pitit, ti pitit yo piti
Mr. S: Non, pale a klas yo non. [ ] mwen pa konnen [ ].
Scott: = ti piti yo pli piti //pase yon foumi.]
Mr. S: //Murana vinn chita.] Pase ki sa?
Scott: Pase yon foumi.
Mr. S: OK.
Manel: Yo fè pitit?
Scott: Non, yo vinn grandi yo fè pitit.

Lines 38-45

Mr. S: Joel, um, James?
James: Yeah, konsa m ap di Scott. E si se pitit ki fè pitit avèk manman?
Scott: Mwen pa fouti di sa. Mwen pa fouti pale de sa. Mwen menm [ ] di [ ] te vinn gen granmanman, granmanman. E sa m te di. E sa m te di. Mwen pa t pale afè pitit al fè sex avèk manman yo.

Lines 46-98

Mr. S: Manel?
Manel: M gen plizyè kèsyon pou Scott.
Scott: Yes?
Claudie: Bay dè.
Manel: Mwen menm m mande ou konsa, ke konben ou te pran la, ou te al lakay ou avè-l an prèmyeman?
Scott: Oh, mwen te pran yon gwo - m te gendwa pran a penn dè, dis oswa senk yo konsa.
Mireille: //[ ] Scott ki te al fe bay [ ]?]
Manel: //Eske ou ka di konben] pitit yo fè pa jou?
Scott: Konben pitit yo fè pa jou? Koman m fè konnen? Se blok zè yo fè.
Manel: Epi ou di //konsa ou gen 30?]
Murana/ Mireille: //Kijan [ou fè] konte yo?] Kijan [ou fè] konte yo?
Claudie: Non, lè kalmason ponn zè gen plizyè blok, ou pa konn sa?
Manel: No -
Claudie: Konn gen plizyè.
Manel: No -
Mireille: Kite Scott defann tèt li!
Claudie: Non, si m konn wè l, se nomal pou m di l.
Manel: Non, Scott ta sipoze di m konsa //konben pitit ke yo fè] paske, ou te gen 10 =
Mireille: //Scott ki sipoze defann tèt li.]
Scott: Ou konn sa ki fè m di apenn de 30 yo? Paske, ti pitit pitit piti yo, sa k menm fenk fèt yo, m konte yo. Se sa m konte yo paske, paske m konn wè ke yo konn, ke yo konn, ke yo konn kole nan po galon an.
Manel: = OK, Mèt S - Scott, m kwe manti se manti Scott ap bay.
Mr. S: //Poukisa?]
Scott: //Non, m pap, m pap.]
Manel: Paske, tande, wi! Ou gen 10 - tande, //tande, tande, tande]
Scott: //OK OK OK OK], m ap pote yo pou ou demen si dye vè, [ ] tout kalmason [ ].

[Commotion]

Mr. S: Tande, lèse l pale [ ] repons. Pale non.
Manel: = ou gen 10 kalmason. Lè ou gade nan sa ou mete a, ou gen 30. E rès yo, rès yo pa fè pitit?
Scott: Mwen te di a penn de 30 yo. E pa sa m te di?
Manel: Non, m mande ou, eske rès yo fè pitit?
Scott: Yes, yo fè pitit.
Manel: [ ] fè pitit?
Scott: Gen *enpè* ki fè pitit.
Manel: E lot yo?
Scott: Lot yo? M pa konnen.
Manel: [ ]

Line 99-100

Mireille: Kijan [ou] fè konnen sa k fè pitit sa k pa fè pitit?

Lines 101-130

Darlene: Men kankou si ou di ou gen 30 kalmason
Scott: Uh hunh.
Darlene: = nan konben *tan* ke chak kalmason fè pitit? //Kankou,] eske yon kalmason ki gen, si l fèt jodia eske demen li ka al fè yon pitit?
Asline: Yes Scott.]
Mr. S: //Bon kèsyon!]

[Commotion, students cry out, some hoot]

Scott: Mwen menm, m di sa! Mwen di konsa *lè yo grandi!* Mwen di lè yo grandi yo fè pitit.
Mr. S: OK, timoun, m mèt di yon bagay? Sa se yon bagay ke m ta renmen konnen paske nou menm n ap fè rechèch sou sa. M ta renmen konnen - bon kèsyon - Scott reponn [ ]

[Renewed commotion]

Scott: OK, mwen menm, men sa m te di, mwen menm, le [ ] te poze m kèsyon sa, [ ] te mande eske menm lè pitit yo fenk fèt la, eske menm lè a yo al fè pitit anko? Mwen menm m te di non. Mwen menm m te di sa se lè yo grandi, yo vinn fè pitit, paske ke, m konn mete -
Darlene: //Kite m mande ou yon kèsyon anko anvan ou finn reponn.]
Scott: /Ou p ap rèt tann mwen fini?]
Darlene: Anvan ou reponn li konsa, 'te m mande ou yon bagay pandan ou di sa. Kankou si ou di konsa ke yo fè pitit, e sa ou te di m, nan konben tan pou yon kalmason grandi?
Scott: Koman m fè konnen?
Darlene: E ben, //Scott]
Scott: = //Kalmason toujou piti.]

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